PRELIMINARY EVALUATION OF THE WATER QUALITY OF TROUT LAKE NIPISSING DISTRICT

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Ministry of the Environment

Ontario

PRELIMINARY EVALUATION

OF THE

WATER QUALITY OF TROUT LAKE

NIPISSING DISTRICT

NELS CONROY, REGIONAL BIOLOGIST

and

WILLIAM KELLER, FIELD TECHNICIAN

BIOLOGY SECTION, WATER QUALITY BRANCH

MINISTRY OF THE ENVIRONMENT

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SUMMARY AND CONCLUSION

The results of a survey carried out in August, 1971 and accessory information provided by other ministries indicate that Trout Lake is a rather typical late oligotrophic or early mesotrophic lake. Lakes in the Precambrian Shield area of Ontario,and in particular mesotrophic lakes, are vulnerable to artificial inputs of nutrients from shoreline development.

The lake reacts slightly acid and the majority of parameters measured were in low concentration. In general, water quality of Trout Lake appeared to be rather uniform except for Four Mile Bay which was significantly more dilute. As expected for this classification of lake, the water was highly transparent and chlorophyll *a* concentrations were low, both factors being indicative of a low level of biological productivity.

Chemical constituents were not significantly higher at inshore areas where effects of shoreline development might be considered to affect the water quality. Bacteriological quality was within the defined limits established by the Ministry except at Sullivan's Creek in early 1972. The consistent presence of faecal coliform bacteria at certain stations may, however, be an early indication of inadequate sewage treatment facilities in certain areas of the lake.

RECOMMENDATIONS

Based on the findings of this report it is recommended that:

1. The source of impairment to water quality as indicated by the bacteriological analysis of inshore samples near Sullivan's Creek be ascertained and corrective measures be implemented.

2. A programme be instituted to provide a detailed evaluation of the adequacy of sewage treatment at existing shoreline developments.

3. Caution be exercised in the approval of further shoreline development that might have a tendency to undermine the water quality of Trout Lake. In particular, the suitability of much of the shoreline area for septic tank-tile bed installations to service private dwellings is questionable since the bedrock is exposed or dangerously close to the surface in many areas. Also, it has been shown that many soils on the Precambrian Shield have a limited ability to absorb nutrients from domestic wastes.

4. Since Trout Lake is an important resource to the North Bay area both as a water supply for the city and a high quality recreational area, it is most desirable that water quality be maintained at its present high level. To this end it is recommended that Trout Lake be incorporated into a self-help chlorophyll *a* Secchi disc monitoring programme to provide an early indication of adverse changes to the lake.

INTRODUCTION

PURPOSE AND SCOPE

The provision and maintenance of high quality water in the Province of Ontario is a responsibility of the Ministry of the Environment and one area of particular concern is the degradation of water quality in lakes of the Precambrian Shield resulting from shoreline cottage and home development. As indicated by Schenk (1971) and Conroy (1971) recreational lakes may be subjected to three major types of water quality impairment:

1) bacteriological contamination leading to a public health hazard.

2) nutrient enrichment leading to excessive growths of algae and/or aquatic weeds (eutrophication), and,

3) acidification from airborne sulphur dioxide contamination leading to an increase in the hydrogen ion concentration of the lake water and a subsequent decline in the lakes' natural productivity.

At the request of concerned citizens in the vicinity of Trout Lake, a preliminary evaluation of Trout Lake was undertaken in August, 1971, to assess its present trophic status. It is the purpose of this report to outline the results of the survey. Accessory information including morphometric data and bacteriological quality were provided by the Ministry of Natural Resources and the North Bay and District Health Unit, respectively.

DESCRIPTION OF THE STUDY AREA

Trout Lake is a relatively large lake in the Precambrian Shield area of Ontario covering 1,700 hectares (4,100 acres) with a shoreline perimeter of 60 km (37 miles) covering portions of the townships of East and West Ferris and Widdifield. The most westerly end lies within the boundaries of the City of North Bay. The lake drains to the southeast via the Mattawa River, joining the Ottawa River at the Village of Mattawa.

Historically, Trout Lake formed a link in the major canoe route connecting the St. Lawrence River with Georgian Bay of Lake Huron. At present the lake is used mainly for boating and cottaging, and although the lake produces some large walleye, lake trout and landlocked Atlantic salmon, fishing pressure remains light, probably as a result of its proximity to the high quality warm-water fishery of Lake Nipissing. The shoreline is moderately developed with 650 permanent residences and summer cottages and nine resorts.

Only a small area at the west end of the lake is provided with a sewage collector system delivering to the North Bay sewage treatment plant. The remaining development is serviced by individual septic tank tile-bed systems draining to the lake. Water from Trout Lake provides the entire drinking water supply for the City of North Bay (population 46,734; Municipal Directory, 1972).

METHODS

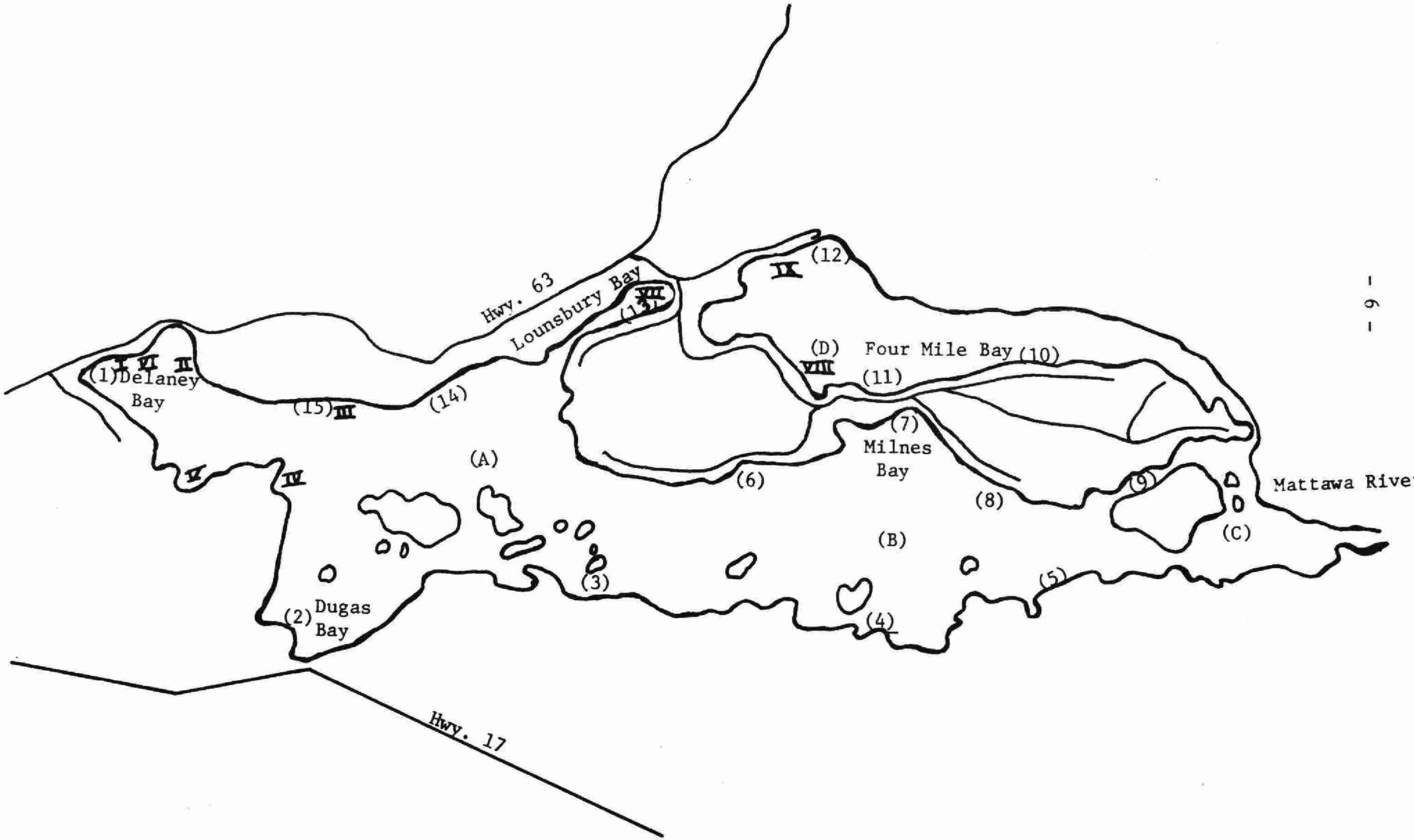
On August 26 and 27, 1972, sampling was carried out at 19 locations on Trout Lake (see figure 1 for locations). Each location was sampled only once. Four stations (A, B, C and D) were located in the main body of the lake distant from potential shoreline sources of impairment. The remaining fifteen stations (1-15) were located around the perimeter of the lake in 'inshore areas'. Emphasis was placed on locating these inshore stations adjacent to the more heavily populated areas of the shoreline.

At each station, two litres of water were collected for chemical analysis at a depth of one metre and shipped to the chemical laboratory of the Ministry of the Environment in Toronto. Analysis performed on these samples included:

pH	calcium
conductivity	magnesium
alkalinity	sodium
acidity	potassium
phosphorus (total & soluble)	silica
nitrogen including nitrate	sulphate
ammonia & Kjedahl nitrogen	carbon

As well, at all stations Secchi disc depths were recorded and one litre composite water samples representing the euphotic zone (zone of significant light penetration, calculated as twice the Secchi disc depth) were collected for analyses of the chorophyll *a* concentration and the identification and enumeration of phytoplankton (algae). Samples for chlorophyll analyses were immediately stabilized with sufficient magnesium carbonate solution (2% w/w) to elevate the pH and retard the breakdown of chlorophyll *a* during

Figure 1: Sketch Map of Trout Lake showing locations of sampling stations.



transportation. These samples were shipped to Toronto and analysed in the Ministry of the Environment's laboratory within 48 hours of the time of collection. The samples for phytoplankton identification and enumeration were preserved with 10 ml of Lugol's iodine solution and shipped to Toronto for microscopic analysis by the Phytoplankton and Eutrophication Unit of the Biology Section. Data on dissolved oxygen and temperature-depth profiles were collected at the four open stations only.

RESULTS AND INTERPRETATION

SECCHI DISC AND CHLOROPHYLL *a*

The depth to which a standard black and white disc referred to as a Secchi disc is visible in the water column provides an index of the water clarity and therefore an indication of the amount of suspended matter in the water. Lakes with high biological activity and therefore a high concentration of algae would have low Secchi disc transparency depths and vice versa. Michalski and Conroy (1972) have shown that lakes influenced by domestic sewage or nutrient enrichment have diminished Secchi disc transparency depth. Further, Vallentyne (1969) has indicated that lakes having Secchi disc readings of less than 3 m are eutrophic or highly productive, while those exceeding 6 m are oligotrophic or highly unproductive.

The Secchi disc depths for Trout Lake are provided in Table iii of the Appendix. The values varied from 3.0 - 5.0 metres. The highest values indicating the most transparent water were from the open lake stations, A , B and D and the lowest value was recorded at station 1 in the extreme east end of the lake. Secchi disc data provided by the Ministry of Natural Resources from the vicinity of stations B and D for May, 1972 are significantly lower than the above data, i.e 3.5 m and 3.8 m, respectively. It is not unusual for lakes to show a pulse of biological activity and therefore diminished Secchi disc depths during the spring of the season.

Chlorophyll *a* is the main photosynthetic green pigment in algae and its concentration can be used as an indication of the extent of biological activity in a lake at the time of sampling. Experience has indicated (see Michalski and Conroy, 1972) that concentrations between 0 and 5 μgm l^{-1} are low and indicate low to moderate algal densities and levels greater than 10 μgm l^{-1} reflect high algal activity. Table 1 provides the results of analyses of composite water samples collected through the euphotic zone for chlorophyll *a* concentrations. The values ranged from 2.0 to 4.8 μg l^{-1} (mean of 2.9 μgm l^{-1}) and a pattern in the variation could not be detected. The values as provided above, attest to the relatively low biological activity of Trout Lake.

Both the Secchi disc transparency depths and chlorophyll *a* concentrations are measures of the water clarity and, in the manner demonstrated above, can be used as an indicator of the trophic status of a lake. Recently, Brown (1972, see also Michalski and Conroy, 1972), has indicated that a near-hyperbolic relationship exists between chlorophyll *a* concentrations and Secchi disc readings for lakes in areas where the Precambrian Shield is exposed. This relationship is depicted in figure 4 with the averaged data (19 points) for Trout Lake included on the graph. The position of Trout Lake on this curve reflects it's oligo-mesotrophic nature. That is, in trophic status, Trout Lake is between Lake Ontario and Lake Huron.

NOTE: The phytoplankton data are not available for this report but will be recorded on file in the Biology Section of the Ministry of the Environment, Sault Ste. Marie.

TEMPERATURE & DISSOLVED OXYGEN PROFILES

Dissolved oxygen and temperature-depth profiles for stations A, B, C and D are tabled below (table 1) and shown graphically in figures 2 & 3.

Although surface temperatures were relatively constant (17.8 - 18°C) the temperature-depth profiles depicted in figure 2 showed considerable variation from station to station. At station A a weak thermocline was established between 10 and 15 metres. In contrast a strong thermocline was present between 9 - 11 m at station B. Station C near the outlet had a poorly defined irregular thermocline between 6 and 10 metres, while stations D (Four Mile Bay) was similar to station B - demonstrating a well defined thermocline between 8 & 11 metres.

TABLE 1

TEMPERATURE AND DISSOLVED OXYGEN PROFILES

FOR STATIONS ON TROUT LAKE, AUGUST 1971

STATION A

Depth (m)	Temp°C	Dissolved Oxygen %	Dissolved Oxygen mg l^{-1}
1	17.8	94	8.7
3	17.6	94	8.7
5	17.6	'94	8.7
7	17.5	94	8.7
9	17.0	94	8.7
11	16.1	91	8.7
13	13.0	83	8.5
15	10.5	67	7.2

STATION B

Depth (m)	Temp°C	Dissolved Oxygen %	Dissolved Oxygen mg l^{-1}
1	18	92	8.4
3	18	92	8.4
5	17.8	93	8.4
7	17.5	94	8.5
9	17.1	94	8.7
11	11.0	70	8.9
13	10.5	68	7.8

STATION C

Depth(m)	Temp°C	Dissolved Oxygen %	Dissolved Oxygen mg l^{-1}
1	17.8	88	8.1
3	17.8	88	8.1
5	17.1	88	8.3
7	14.0	87	8.7
9	13.0	80	8.4
11	9.5	56	6.2
13	9.5	56	6.3

STATION D

Depth(m)	Temp°C	Dissolved Oxygen %	Dissolved Oxygen mg l^{-1}
1	18	76	7.0
3	17.5	75	7.0
5	16.9	72	6.8
7	16.5	70	6.6
9	12.2	68	7.1
11	8.5	63	7.0
12	8.5	63	7.0

FIGURE 2: Dissolved Oxygen Distribution with Depth for Trout Lake August 26, 27, 1971.

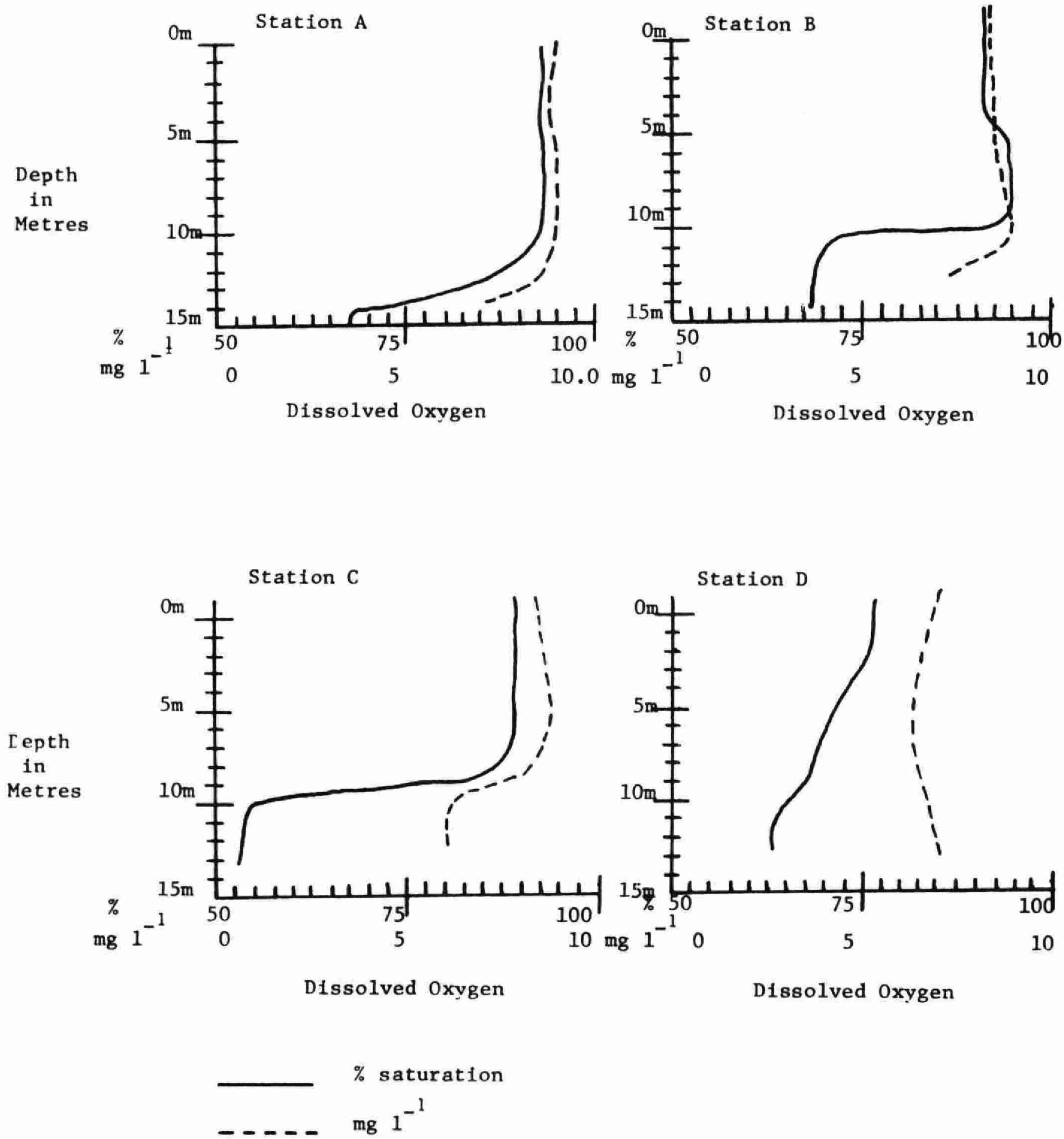
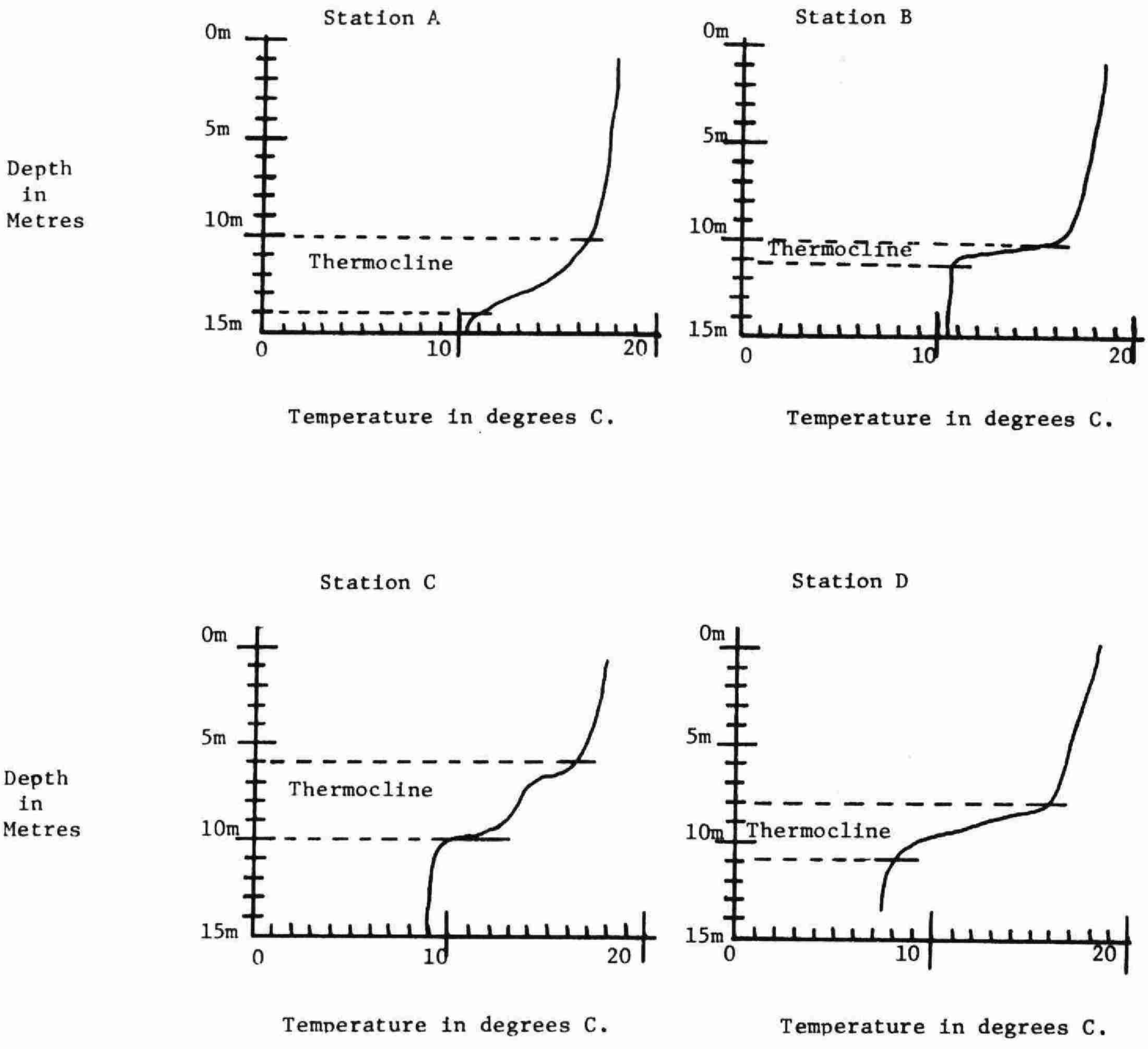


FIGURE 3: Temperature Distribution with Depth for Trout Lake
August 26, 27, 1971.



The definition and strength of the thermocline is important in determining the vertical distribution of chemical species and dissolved gases in a lake. A well established thermocline effectively isolates the surface water (epilimnion) from the bottom water (hypolimnion)and acts as a barrier to the diffusion of chemical species and dissolved gases between the bottom and surface water. Of particular importance is the concentration of dissolved oxygen present in the hypolimnion. Cold water fishes that inhabit the hypolimnion such as lake trout, salmon and herring, require at least 5 to 6 mg l^{-1} oxygen for survival. If the volume of the hypolimnion is small, and the rate of utilization of oxygen at the mud-water interface by biological and chemical oxidation is high, it is easy to deplete the oxygen in the hypolimnion (because the thermocline prevents the diffusion of oxygen in the surface waters from replenishing that of the hypolimnion), thus destroying it as a suitable habitat for cold water fishes.

As well, Brydges, 1971, has shown that when the mud-water interface is depleted of oxygen the nutrients, particularly phosphorus which is tied up in the sediment, begin to be released to the hypolimnion and become available to phytoplankton during periods of destratification. This can lead to an increase in algal biomass to the extent that nuisance blooms of algae occur. The decomposition of dead cells from such a bloom can further deplete the oxygen supply in the hypolimnion.

The open-lake stations (A, B and C) showed a tendency toward clinograde oxygen distributions (an exponential decline in oxygen in the deeper waters) in mid August, 1971. Station D, in Four Mile Bay, had a non-diminishing oxygen distribution with depth with a slight tendency to an oxygen deficit in the mid-water areas above the thermocline. The tendency toward an oxygen deficit in the hypolimnion at stations A, B and C although not critical is a further indication of the lake oligotrophic or early mesotrophic nature of Trout Lake suggested by chlorophyll *a* and Secchi disc relationships. As pointed out by Brydges (1971), mesotrophic lakes are vulnerable to additions of domestic wastes. There is, however, no indication to suggest that the early mesotrophic status is related to already existing artificial nutrient inputs. Michalski and Robinson (1971) pointed out that it is not uncommon for many relatively small, well protected undeveloped lakes in the Precambrian Shield to show clinograde oxygen curves during summer stratification.

Lakes tend to become less suited to most water oriented recreational activities as they become more eutrophic. That is, oligotrophic lakes: defined as deep, highly transparent bodies of water characterized by low productivity and a meagre supply of nutrients and with bottom waters well supplied with oxygen, are usually the most esteemed lakes for recreational activity. Eutrophic lakes, on the other hand, are turbid, productive lakes characterized by high concentrations of nutrients and an oxygen deficit in the bottom waters and are less desirable for water-oriented recreation.

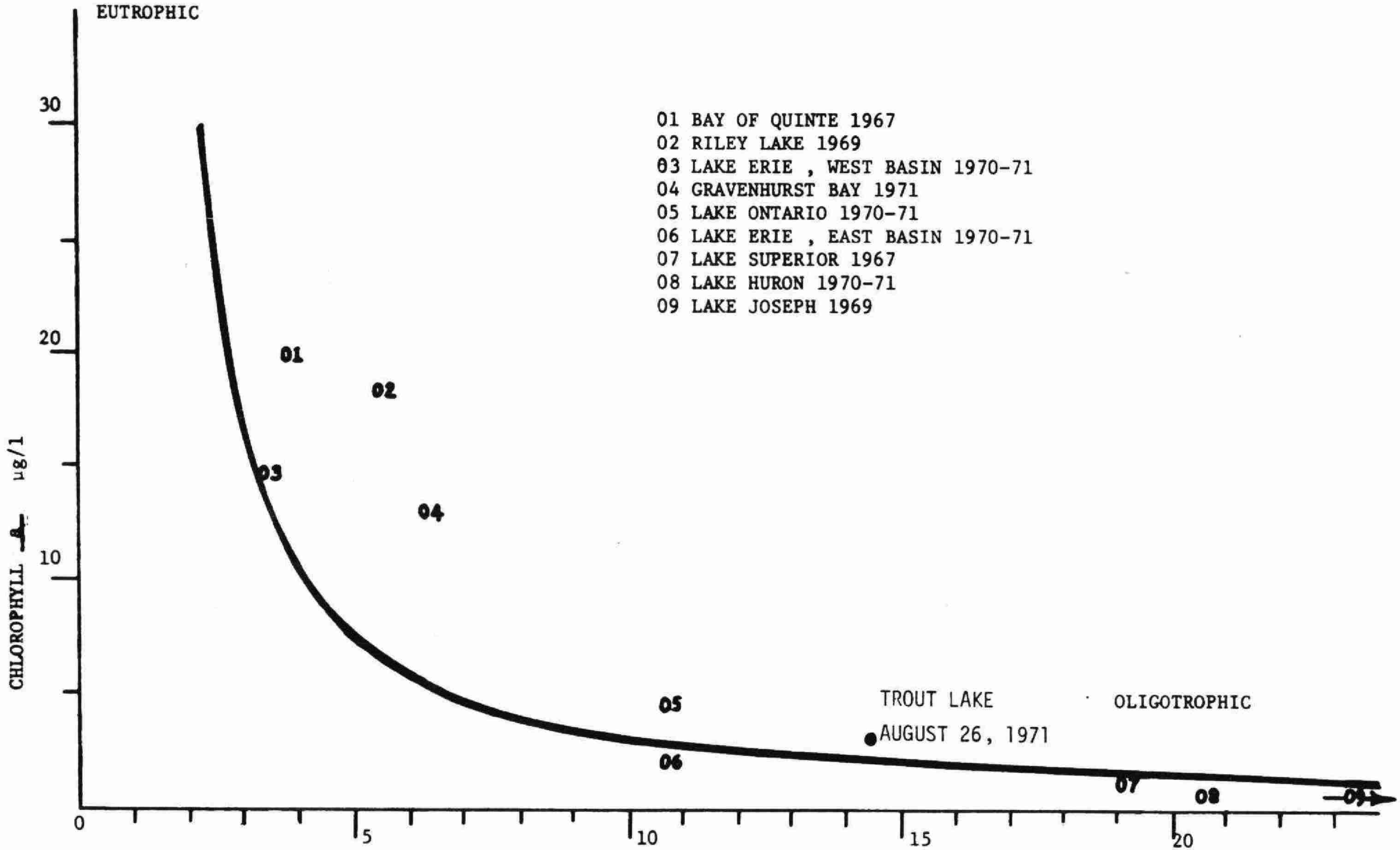


Figure 4: The relationship between chlorphyll a and Secchi disc as determined from Ontario Lakes surveyed in 1971. The value for Trout Lake equals the mean of 19 stations.

WATER CHEMISTRY

The results of the chemical analyses of water samples from Trout Lake are provided in Tables 1 and 11 of the Appendix and a limited interpretation of the results follows:

pH, Alkalinity, Acidity and Conductivity

The hydrogen ion concentration was relatively similar throughout the lake. The pH as reported by laboratory pH measurements was neutral, varying from 6.9 to 7.1. Data provided by the Ministry of Natural Resources for two stations proximal to stations B and D as shown in Figure 1 record a pH of 6.5 on May 24-26, 1972, as measured at the time of sampling.

Alkalinity, a measure of the lake's acid - buffering capacity ranged from 8 mg l^{-1} to 14 mg l^{-1} as Ca CO_3. Values tended to be highest in the eastern portion of the lake (stations 2, 14, 15 and A) and lowest in Four Mile Bay (stations 10, 11, 12 and D). The alkalinities recorded by the Ministry of Natural Resources for May 24-26, 1972, were 13.7 mg l^{-1} as Ca CO_3 in the vicinity of station D and 20.5 mg l^{-1} in the vicinity of stations A and B.

Lakes in the Precambrian Shield characteristically react slightly acid ($pH < 7.0$) and are often supersatuated with carbon dioxide (Kramer, 1968 and Conroy 1971). Samples of water from these lakes tend to release the excess carbon dioxide to the atmosphere on sitting and thus the pH increases and the alkalinity (a measure in part of the carbon dioxide content) declines. This tendency represents the most probable explanation

for the discrepancy between the values for pH and alkalinity reported by the Ministry of Natural Resources and the Ministry of the Environment.

Conductivity (a measure of the ionic strength of the water) was similar throughout Trout Lake (68 - 71 μmho cm^{-1} @ 25°) with the exception of Four Mile Bay (stations 10, 11 and D) where values were significantly lower (53 μmho cm^{-1} @ 25°C). The data recorded by the Ministry of Natural Resources was similar, i.e. conductivity in the vicinity of stations A and B was 70 μmho cm^{-1} @25°C and 50 μmho cm^{-1} @ 25°C in Four Mile Bay. The conductivity indicates that the waters of Trout Lake are very dilute with an estimated total dissolved solids concentration of less than 30 mg l^{-1}

Major Cations

The concentrations of the major cations in Trout Lake were low and relatively uniform. The calcium and potassium concentration was lower in Four Mile Bay than at other stations while the reverse was true for sodium and magnesium concentrations. These data are provided in Table 2 below:

TABLE 2

SUMMARY OF THE CONCENTRATION OF MAJOR CATIONS IN TROUT LAKE, AUGUST 1971

	Four Mile Bay	Other Stations
Calcium	5 mg l^{-1}	6 mg l^{-1}
Magnesium	1 mg l^{-1}	1 mg l^{-1}
Sodium	3-4 mg l^{-1}	2 mg l^{-1}
Potassium	0.9-1.1 mg l^{-1}	1.2-1.3 mg l^{-1}

Major Anions (Excepting Bicarbonate)

The major anion in Trout Lake was sulphate (10-13 mg l^{-1}). The concentration of sulphate in waters of the Precambrian Shield is of major concern since it has been shown that the addition of sulphuric acid derived from atmospherically-conveyed sulphur dioxide from industrial activity has the potential of acidifying lakes and causing a reduction in biological activity. Lakes with low buffering capacity (bicarbonate concentration) such as Trout Lake and other lakes in the Precambrian Shield area of Ontario, are particularly susceptible to acidification by additions of small amounts of sulphuric acid.

Although the concentration of sulphate may show considerable variation (Hutchinson, 1957) unpolluted oligotrophic lakes in the Precambrian Shield area of Ontario normally contain less than 15 mg l^{-1}. The sulphate concentration of Trout Lake was less than 15 mg l^{-1} and thus is not of concern at this time. As mentioned earlier, the pH of Trout Lake was not depressed as is the case in lakes suspected of being acidified by sulphur dioxide pollution, however, owing to the poor buffering capacity of Trout Lake waters the potential for future acidification is of concern.

Silica was low throughout the lake ranging from 1.3 to 2.1 mg l^{-1}. In contrast to most other parameters the silica concentration measured in Four Mile Bay tended to be slightly higher than in the rest of the lake.

Carbon

Concentrations of both total and inorganic carbon were quite constant throughout the lake. Total carbon ranged from 7.5 to 8.5 mg l^{-1} of which 1.5 - 2.0 mg l^{-1} was in the inorganic form.

Phosphorus

Total phosphorus concentrations in Trout Lake ranged from 004 to .014 mg l^{-1} with a mean value of .007 mg l^{-1} . Total phosphorus varied throughout the lake, however, the variations did not appear to follow any pattern.

Nitrogen

Free ammonia concentrations in Trout Lake ranged from .01 to .04 mg l^{-1} as N. Stations located in inshore areas were generally slightly higher in ammonia than offshore stations. Also, stations located in Four Mile Bay had slightly lower concentrations of ammonia than stations in the remainder of the lake. The highest ammonia levels (0.04 mg l^{-1}) were present at stations 1 and 15 located in the western extremity of the lake.

Concentrations of total Kjeldahl nitrogen varied by a factor of 3 throughout the lake. The lowest value was at station C (0.15 mg l^{-1} as N) and the highest was 0.48 mg l^{-1} at station 6. Concentrations of Kjeldahl nitrogen tended to be highest in the western portion of Trout Lake.

Nitrate concentrations followed a pattern similar to that of Kjeldahl nitrogen in that values tended to be slightly higher in the western

portion of the lake. Concentrations of nitrate varied from 0.07 mg l^{-1} as N (station C) to 0.11 mg l^{-1} (stations 15 and B).

The concentrations of carbon,nitrogen and phosphorus measured in Trout Lake indicated that the lake was nutrient impoverished and in this respect typical of oligotrophic Precambrian Shield lakes.

BACTERIOLOGICAL QUALITY

Selected inshore areas of Trout Lake are routinely monitored during the summer for the bacteriological quality by staff of the Nipissing North Bay and District Health Unit. Data for their 1971 and 1972 programmes are summarized in Tables 3 and 4 below.

This Ministry (OWRC, 1970) recommends that total and faecal coliform bacteria should not exceed densities of 1000 and 100 per 100 ml respectively for body contact recreational activities such as swimming and bathing. Further, the criteria should be based on the geometric mean of more than ten samples per month. During 1971 all stations sampled met the Ministry's criteria based on the geometric mean of ten or more samples although individual counts at several stations occasionally exceeded both total and faecal coliform criteria. In particular, station V (Camelot Park) had values of 2000 total coliforms and 1600 faecal coliforms on June 22, 1971. In 1972 station 11 (Sullivan's Creek) showed a mean total coliform concentration of 1968 per 100 ml and faecal coliform concentrations of 144.5 per 100 ml. The range of this station was .28 - 79,000 and 0 - 17,000 total and faecal coliforms per 100 ml, respectively, and thus did not meet the Ministry's criteria for body contact recreational activities.[1]

Since faecal coliforms in particular indicate contamination originating from man or other mammals, the consistent presence of faecal coliforms at certain sampling locations may be indicative of improperly functioning sewage disposal facilities. Although not presenting a direct public health hazard as defined above for body contact recreation, these may be indicative of the potential for nutrients to gain access to the lake from the same source and accelerate the eutrophication process.

FOOTNOTE: 1

Staff of the North Bay and District Health Unit have investigated the problem at Sullivan's Creek and believe that the major contributor to the high total and faecal coliform levels was runoff from landscaping operations at new housing developments where animal manure was used for fertilizer. In the past, sewage discharges were a problem on Sullivan's Creek, however, all septic tanks have now been completed and are functioning. The area has been dye tested and no direct sewage discharges have been found.

TABLE 3

RANGE AND GEOMETRIC MEAN CONCENTRATIONS OF TOTAL (TC) AND FAECAL COLIFORM BACTERIA (FC) AT SELECTED STATIONS ON TROUT LAKE, 1971.

Station #	Location	Geometric Mean TC	Geometric Mean FC	Range TC	Range FC
I (14)	Natural Resources beach	44.0	7.4	6-620	0-55
II (14)	Sullivans Creek	70.1	42.1	20-600	2-215
III (14)	Anita Avenue	4.2	1.9	0-225	0-185
IV (14)	Sage Park	34.5	12.3	10-230	0-230
V (14)	Camelot Park	32.0	16.7	0-2000	0-1600
VI (14)	Crawford Marina	14.4	4.3	5-52	0-50
VII (14)	One Mile Bay	25.6	9.2	10-90	0-90
VIII(14)	Four Mile Bay (East)	28.4	9.0	5-65	0-44
IX (13)	Four Mile Bay (West)	11.0	6.6	0-235	0-140

( )= number of samples

TABLE 4

RANGE AND GEOMETRIC MEAN CONCENTRATIONS OF TOTAL (TC) AND FAECAL COLIFORM BACTERIA (FC) AT SELECTED STATIONS ON TROUT LAKE, EARLY SUMMER, 1972.

Station #	Location	Geometric Mean TC	Geometric Mean FC	Range TC	Range FC
I (10)	Natural Resources Beach	14.2	3.5	0-100	0-25
II (9)	Sullivans Creek	1968.0	144.5	28-79,000	0-17000
III (10)	Anita Ave.	2.9	2.0	0-50	0-6
IV (10)	Sage Park	7.8	2.6	0-62	0-18
V (10)	Camelot Park	4.1	1.5	0-34	0-8
VI (10)	Crawford Marina	8.0	2.1	0-110	0-15
VII (10)	One Mile Bay	6.1	3.0	0-88	0-20
VIII(10)	Four Mile Bay (East)	4.2	2.4	0-72	0-38
IX (10)	Four Mile Bay (West)	3.4	1.4	0-134	0-38

( ) = number of samples.

A P P E N D I X

GLOSSARY

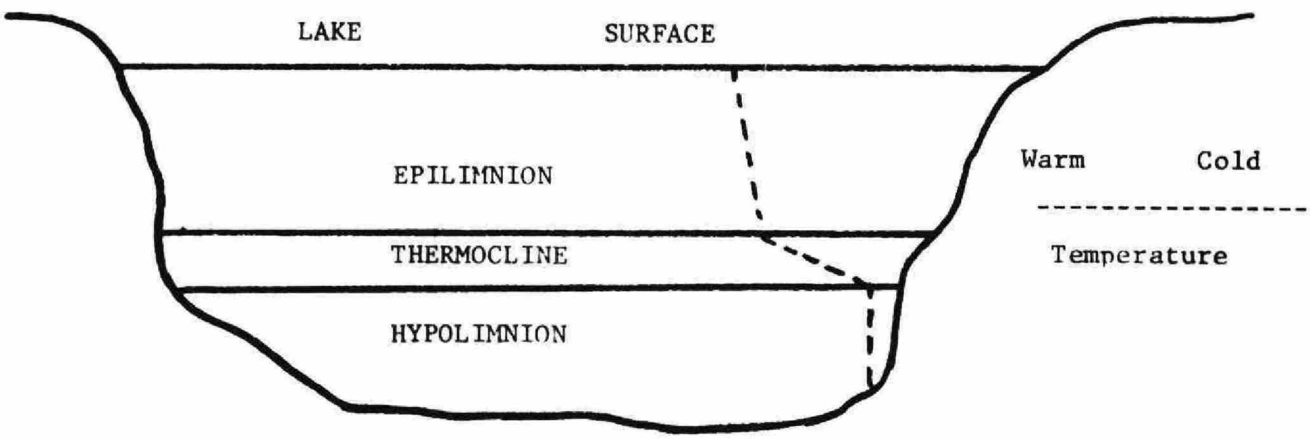
ACIDIFICATION - the process of becoming more acid - of increasing the hydrogen concentration. The standard measure of the hydrogen ion concentration is pH

COLIFORMS - a classification of bacteria normally associated with the digestive tract of animals used as an indicator of water quality impairment

EPILIMNION - lakes which show thermal stratification have three distinct layers. The upper layer of water in which the temperature is relatively uniform is the epilimnion (see figure A)

FIGURE A

Sketch of cross-section of theoretical lake during thermal stratification indicating water layers and temperature distribution



EUPHOTIC ZONE - the intensity of light diminishes as it passes through water until at some depth there is insufficient light to carry on photosynthesis This zone of significant light penetration is the euphotic zone

EUTROPHIC - lakes are classified into three catagories on the basis of the biological activity - those with high biological activity and large nutrient concentrations are eutrophic. Characteristicly eutrophic lakes are shallow, warm and highly turbid (see oligotrophic, mesotrophic and trophic status)

EUTROPHICATION- the process by which lakes become increasingly enriched in nutrients. It refers to the entire complex of changes which accompany nutrient enrichment including dense growth of algae and aquatic weeds.

FAECAL COLIFORMS - bacteria associated with recent faecal pollution from man and other animals.

HYPOLIMNION - the uniformly cold layer of water lying beneath the thermocline in thermally stratified lakes, see figure A.

MESOTROPHIC - those lakes with a moderate supply of nutrients and moderate biological activity, i.e. a trophic status lying between oligotrophic and eutrophic.

OLIGOTROPHIC - lakes with a meagre supply of nutrients and low biological activity. Characteristically oligotrophic lakes are deep, cold water, highly transparent bodies of water.

pH - expression of the hydrogen ion activity of solutions = the negative logarithm_{10} of the molar concentration.

THERMOCLINE- the mid layer of water in thermally stratified bodies of water in which the rate of change of temperature is a maximum.

TROPHIC STATUS - lakes are classified on the basis of the degree of nutrient enrichment and biological activity into three integrating types: oligotrophic, mesotrophic and eutrophic. Additions of nutrients to infertile lakes (oligotrophic) tend to make them mesotrophic and with contimued enrichment will become eutrophic.

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TABLE I ANALYTICAL RESULTS, TROUT LAKE, AUGUST 26 and 27, 1971

STATION	DATE	PH	Cond. umho per cm^3	Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Phosphorus		Nitrogen		
						Tot.	Sol.	Free Ammonia	Total Kjeldahl	Nitrate
1	26/8/71	7.0	70	12	2	.012	<.001	.04	0.33	.10
2	26/8/71	7.0	71	12	2	.008	<.001	.03	0.30	.10
3	26/8/71	7.0	69	12	2	.010	<.001	.03	0.29	.10
4	26/8/71	7.0	70	12	2	.009	.001	.03	0.25	.10
5	27/8/71	6.9	70	14	2	.005	<.001	.03	0.16	.09
6	26/8/71	6.9	70	14	2	.014	<.001	.03	0.48	.09
7	27/8/71	6.9	70	10	2	.004	<.001	.03	0.25	.08
8	27/8/71	6.9	71	12	2	.006	<.001	.02	0.28	.08
9	27/8/71	7.1	69	12	2	.008	<.001	.02	0.21	.09
10	26/8/71	7.0	53	8	2	.006	<.001	.02	0.21	.08

TABLE 1 ANALYTICAL RESULTS, TROUT LAKE, AUGUST 26 and 27, 1971

STATION	DATE	PH	Cond. umho per cm^3	Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Phosphorus		Nitrogen		
						Tot.	Sol.	Free Ammonia	Total Kjeldahl	Nitrate
11	26/8/71	6.9	53	8	4	.006	<.001	.02	0.20	.08
12	26/8/71	6.9	70	8	3	.008	<.001	.02	0.28	.10
13	26/8/71	7.0	70	12	2	.007	<.001	.02	0.22	.10
14	26/8/71	7.0	70	12	2	.005	.002	.03	0.20	.10
15	26/8/71	7.0	70	12	2	.008	<.001	.04	0.32	.11
A	27/8/71	7.1	70	12	2	.006	<.001	.02	0.23	.10
B	27/8/71	6.9	69	14	4	.004	.003	.02	0.26	.11
C	26/8/71	6.9	68	14	3	.006	<.001	.01	0.15	.07
D	27/8/71	6.9	53	8	3	.010	.009	.01	0.22	.08
RANGE MEAN		6.9-7.1 7.0	53-71 63.5	8 - 14 11.0	2 - 4 2.4	.004-.014 .007	<.001-.009 <.002	.01-.04 .02	.15-.48 .26	.07-.11 .09

NOTE: ALL VALUES OTHER THAN pH and conductivity are in mg l^{-1}

TABLE II ANALYTICAL RESULTS, TROUT LAKE, AUGUST 26 and 27, 1971

STATION	DATE	CALCIUM	MAGNESIUM	SODIUM	POTASSIUM	SILICA as SiO_2	SULPHATE as SO_4	CARBON Tot. Org.	Inorg.
1	26/8/71	6	1	4	1.3	1.5	11	7.5	2.0
2	26/8/71	6	1	3	1.3	1.5	11	8.0	1.5
3	26/8/71	6	1	3	1.3	1.3	11	7.5	2.0
4	26/8/71	6	1	4	1.3	1.5	11	8.0	2.0
5	27/8/71	6	1	3	1.2	1.4	10	8.0	1.5
6	26/8/71	6	1	3	1.2	1.5	10	8.0	1.5
7	27/8/71	6	1	3	1.3	1.6	10	8.0	1.5
8	27/8/71	6	1	4	1.3	1.3	10	8.5	1.5
9	27/8/71	6	1	3	1.3	1.5	1.3	7.5	2.0
10	26/8/71	5	1	2	1.0	2.0	11	8.0	1.5
11	26/8/71	5	1	2	0.9	2.0	11	8.5	1.5

TABLE II ANALYTICAL RESULTS, TROUT LAKE, AUGUST 26 and 27, 1971

STATION	DATE	CALCIUM	MAGNESIUM	SODIUM	POTASSIUM	SILICA as SiO_2	SULPHATE as SO_4	CARBON Tot. Org.	Inorg.
12	26/8/71	5	1	2	1.1	2.1	11	8.0	2.0
13	26/8/71	6	1	3	1.3	1.7	11	8	1.5
14	26/8/71	6	1	3	1.3	1.5	11	8	1.5
15	26/8/71	6	1	3	1.3	1.7	12	8	1.5
A	27/8/71	6	1	4	1.3	1.9	11	8	2.0
B	27/8/71	6	1	3	1.2	1.3	12	8	1.5
C	26/8/71	6	1	3	1.3	2.1	11	8	1.5
D	27/8/71	5	1	2	1.0	2.1	12	8	1.5
RANGE		5-6	1	2-4	1-1.3	1.3-2.1	10-13	7.5-8.5	1.5-2.0
MEAN		5.8	1	3	1.22	1.7	11	8.0	1.7

NOTE: ALL VALUES IN mg l^{-1}.

TABLE III: Secchi disc readings and chlorophyll *a* concentrations in Trout Lake, August 26, 1971

Station	Chlorophyll *a* (μg l^{-1})	Secchi Disc (metres)
1	3.8	3.0
2	3.1	4.0
3	3.4	3.5
4	4.8	4.0
5	3.0	5.0
6	2.0	4.0
7	2.0	5.0
8	2.0	5.0
9	2.0	5.0
10	3.0	4.0
11	3.4	4.5
12	2.8	5.0
13	2.4	4.5
14	2.6	3.5
15	3.0	5.0
A	3.6	5.0
B	3.6	5.0
C	2.8	4.0
D	2.0	5.0
Range:	2.0-4.8	3.0-5.0
Mean:	2.9	4.4

DATE DUE
